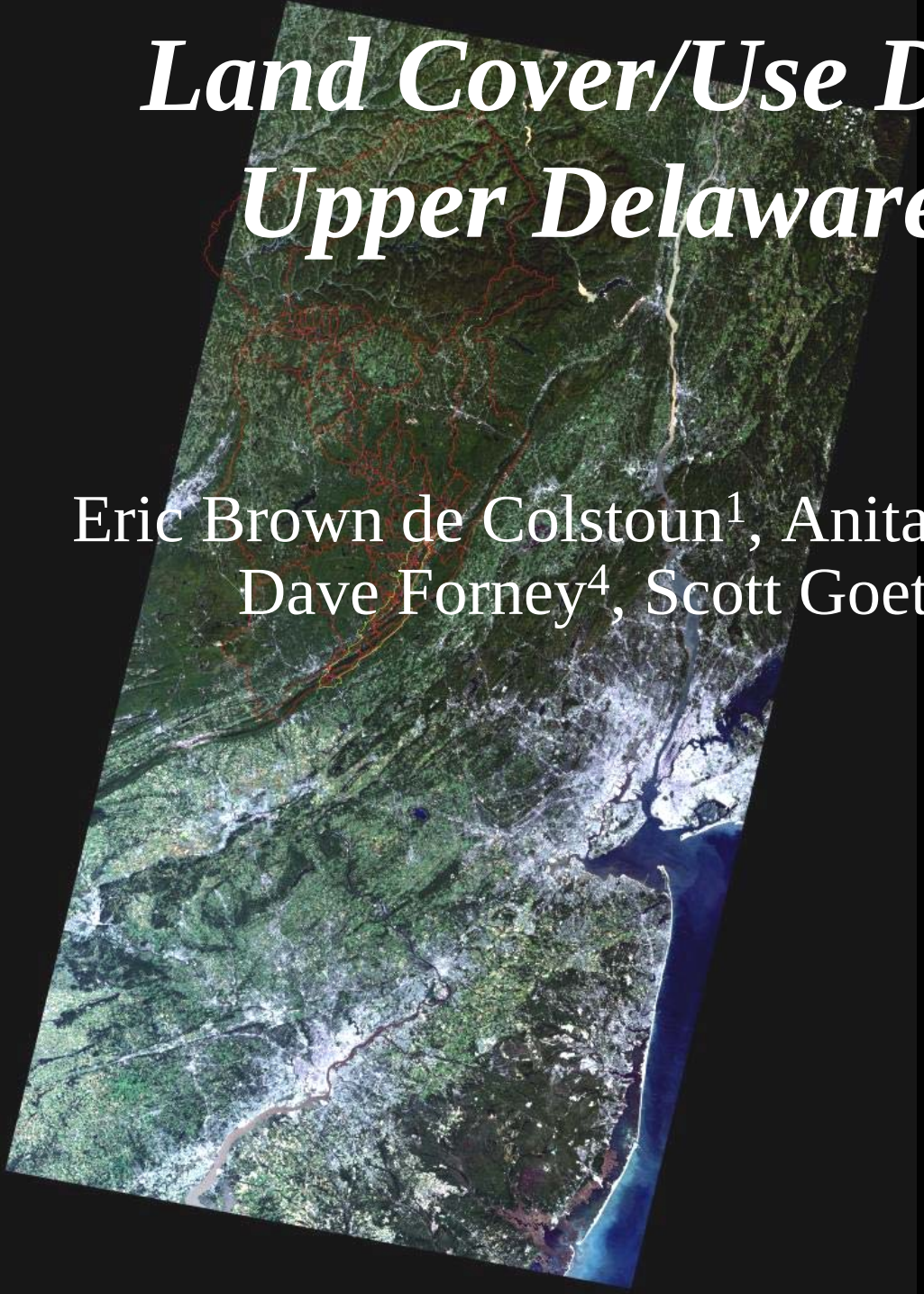
Land Cover/Use Dynamics of the Upper Delaware River Basin



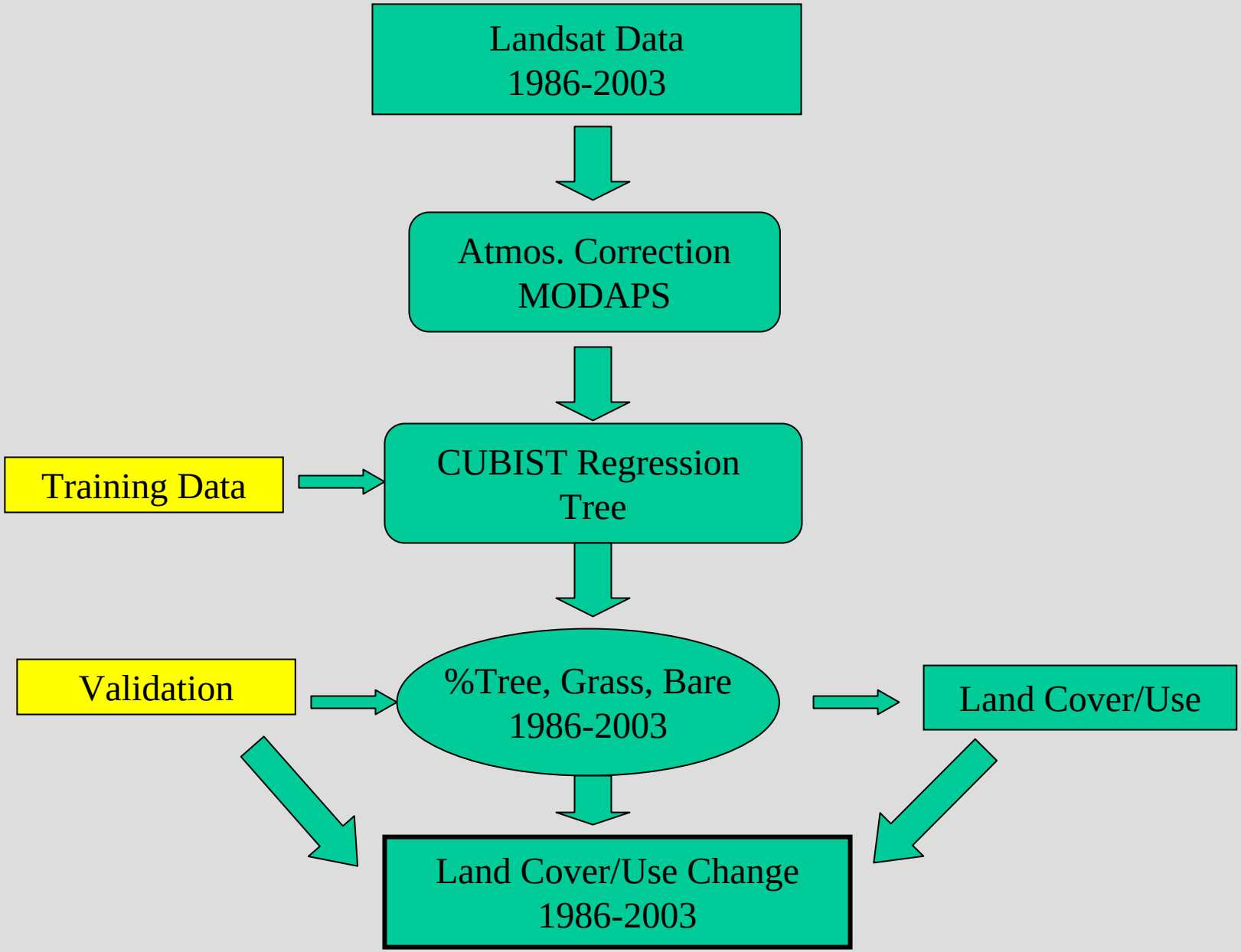
Eric Brown de Colstoun[1], Anita Davis[2], Craig Thompson[3], Dave Forney[4], Scott Goetz[5] and Claire Jantz[5,6]

1 Science Systems and Applications, Inc.
2 National Park Foundation
3 Delaware Water Gap NRA, NPS
4 Upper Delaware SRR, NPS
5 Woods Hole Research Center
6 Mid-Atlantic RESAC, U. of MD

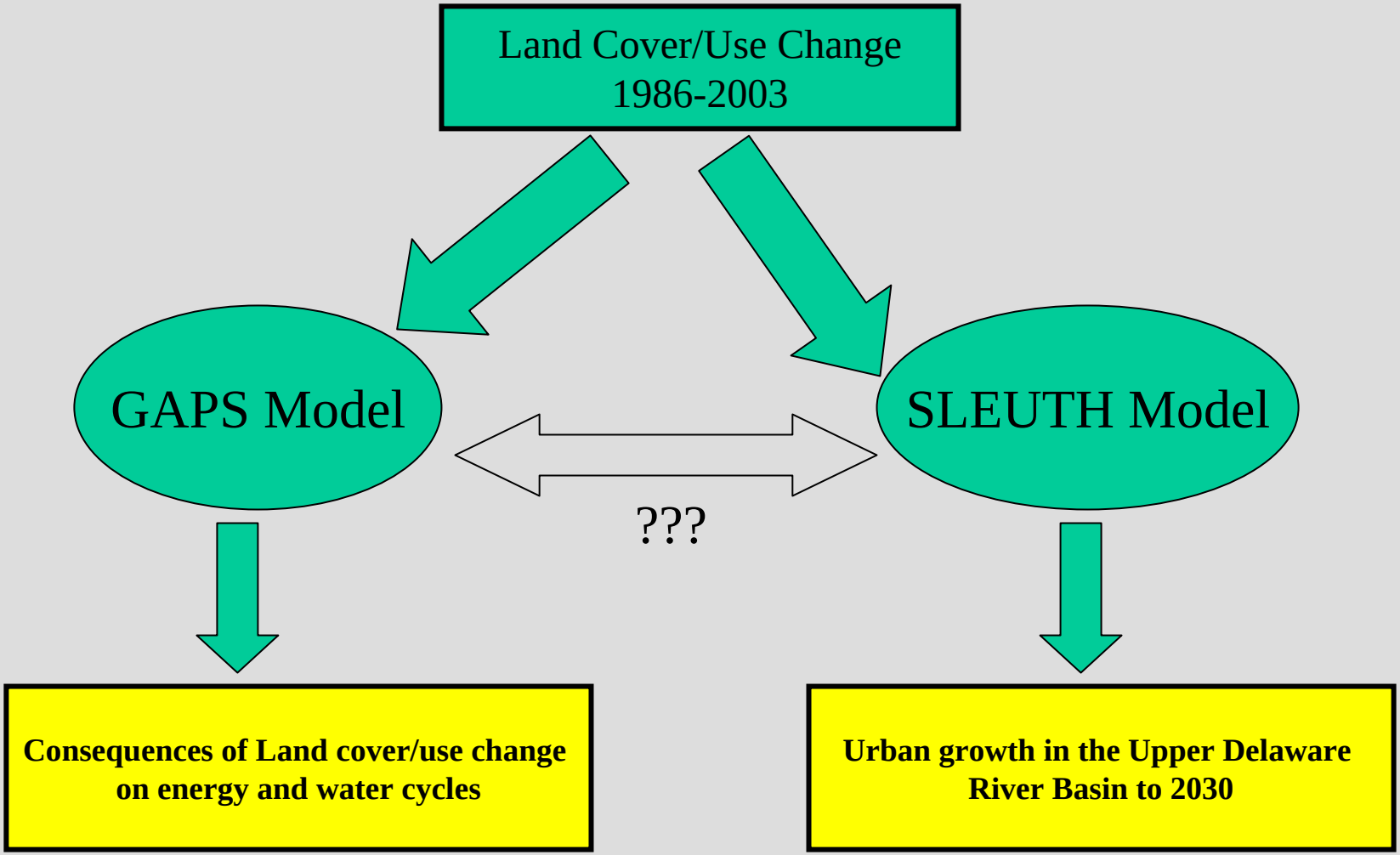
Research Objectives

- To develop cost-effective, satellite-based methods to inventory and monitor land cover/use in and around National Parks in support of the NPS Inventory and Monitoring Program.
- Measure land cover/use changes and trends in the Upper Delaware River Basin from 1986 to the present using Landsat.
- Simulate urban growth to 2030 with various growth scenarios using SLEUTH urban growth model.
- Examine consequences of land cover/use changes on regional water and energy cycles with the GAPS model.

Research Overview



Research Overview (cont.)

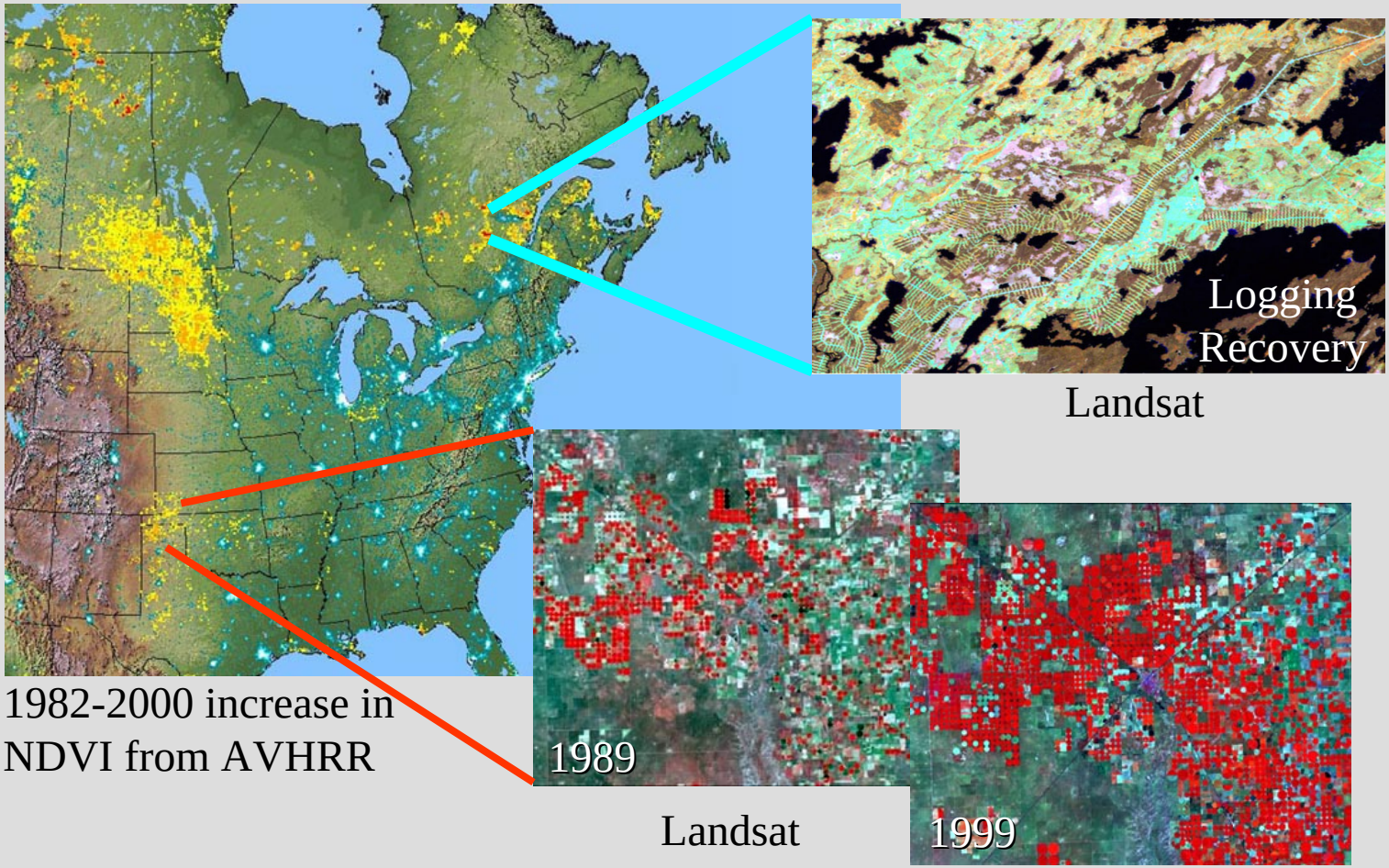


NASA ESE Questions

- How are global ecosystems changing ?
- What changes are occurring in global land cover and land use, and what are their causes ?
- How is the Earth's surface being transformed and how can such information be used to predict future changes ?
- What are the consequences of land cover and land use change for the sustainability of ecosystems and economic productivity ?

Tracking Land Cover/Use Change

• Remotely-sensed data are extremely valuable tools for monitoring both human-induced and natural changes on the surface of the Earth.



1982-2000 increase in NDVI from AVHRR

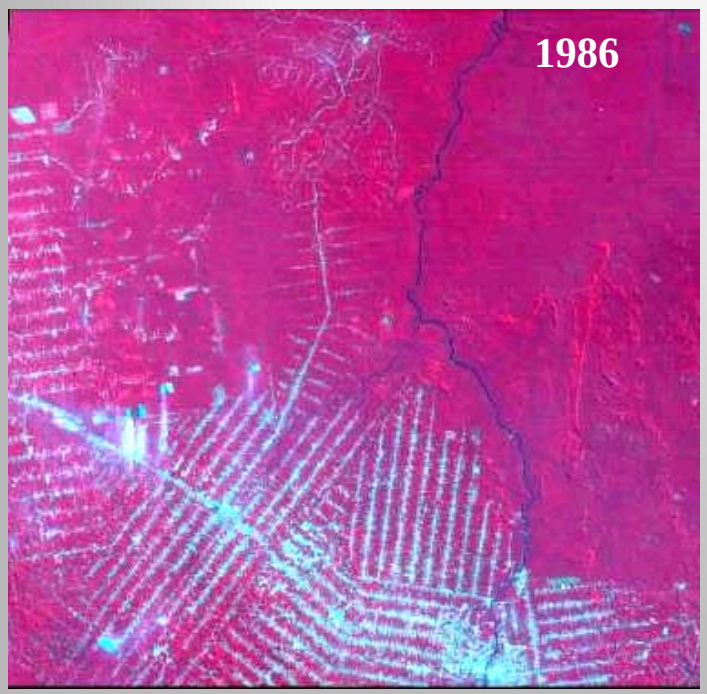
Courtesy C. Tucker, NASA/GSFC

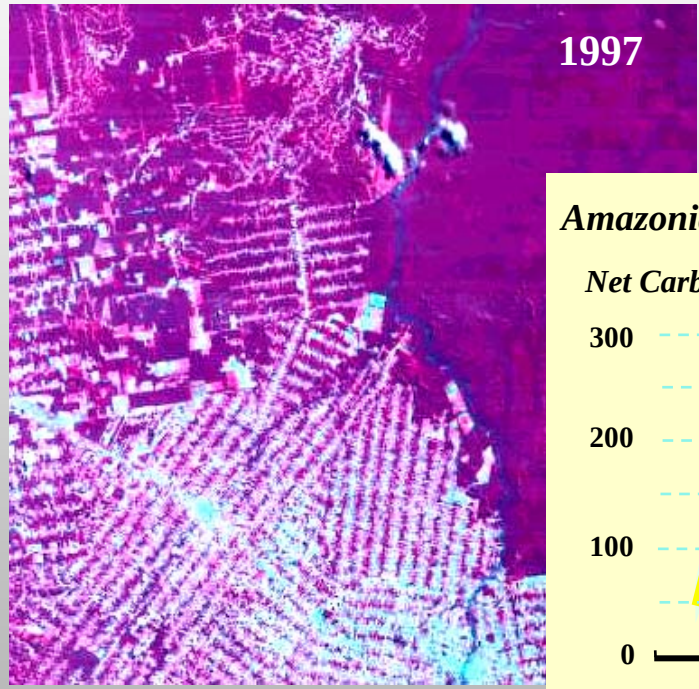
Land Cover Matters

- Land Cover is a principal factor controlling the exchange of energy, water, gases, and nutrients within the Earth system.
- Global change modeling:
  - Boundary conditions for General Circulation Models (GCM).
  - Global biogeochemical and hydrological models.
- Land cover/use change impacts carbon, water and energy at all spatial scales...
- But also Biodiversity, resource management, fire/disaster monitoring...

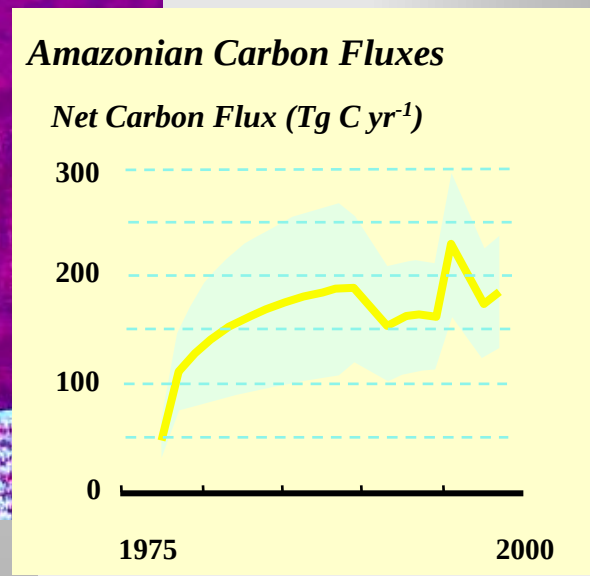
Land Cover Change

•These images show the impact of deforestation in the Amazon on the carbon cycle.





100 km



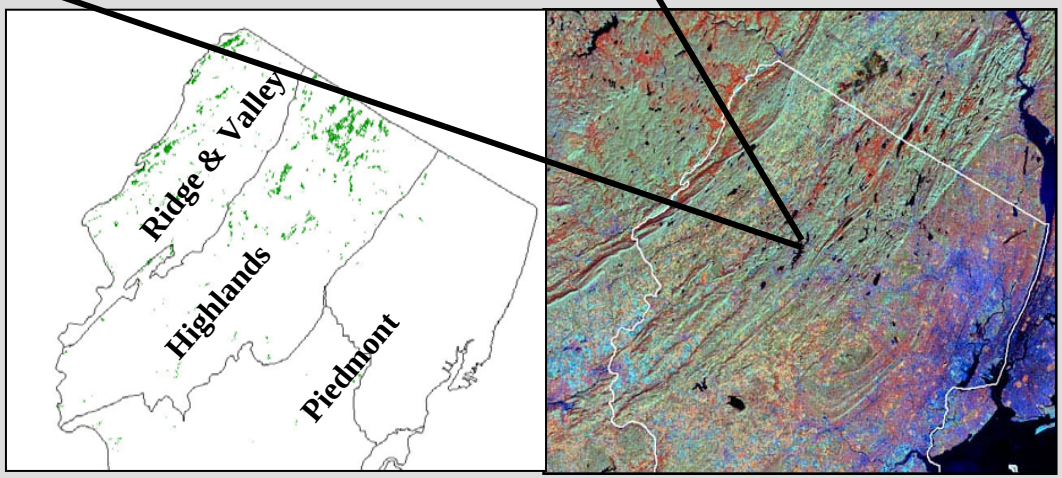
Images courtesy TRFIC–MSU, Woods Hole Research Center

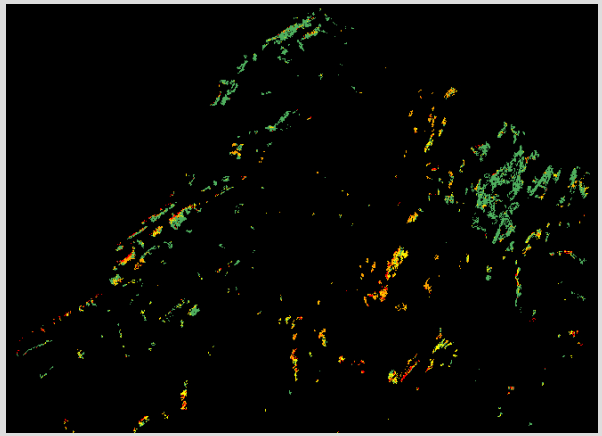
Example: Eastern Hemlock Decline

Ecosystem disturbance and invasive species may be harbingers of climate change.

Example: Eastern Hemlock, an ecologically important conifer in Eastern U.S. Is being affected by infestation of the Hemlock Wooly Adelgid, an aphid-like insect.

Multi-temporal Landsat data have been used to map the distribution of hemlock decline.





non-hemlock	
61% Less than 50% defoliated by 1998	
14% Severely defoliated by 1998	
17% Dead by 1998	
8% Dead by 1992	

D. Royle and R. Lathrop, Rutgers University

Example: Urbanization

Urban growth and sprawl can have significant impacts on:

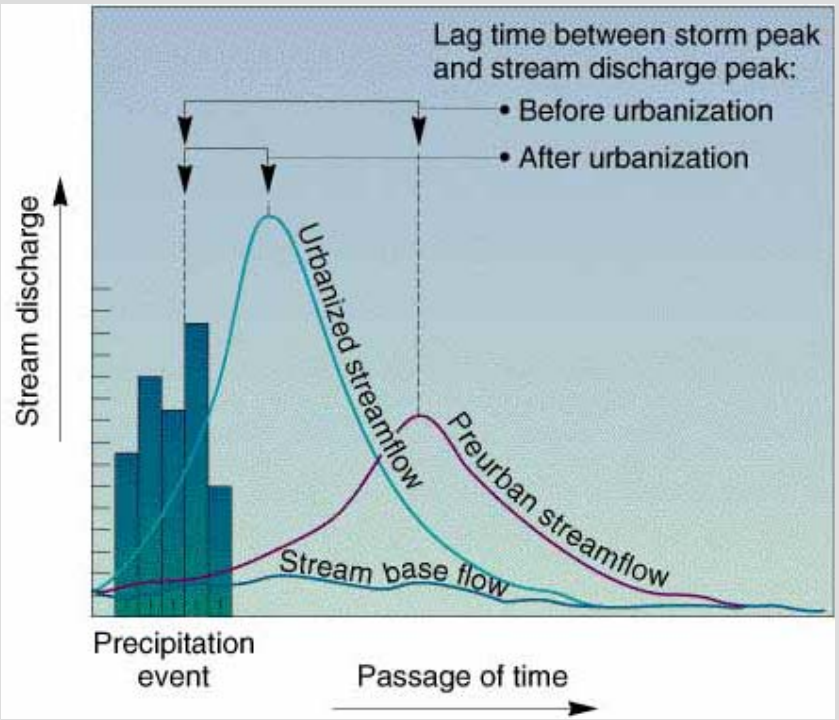
-Local meteorology (e.g. Urban “Heat Islands”).

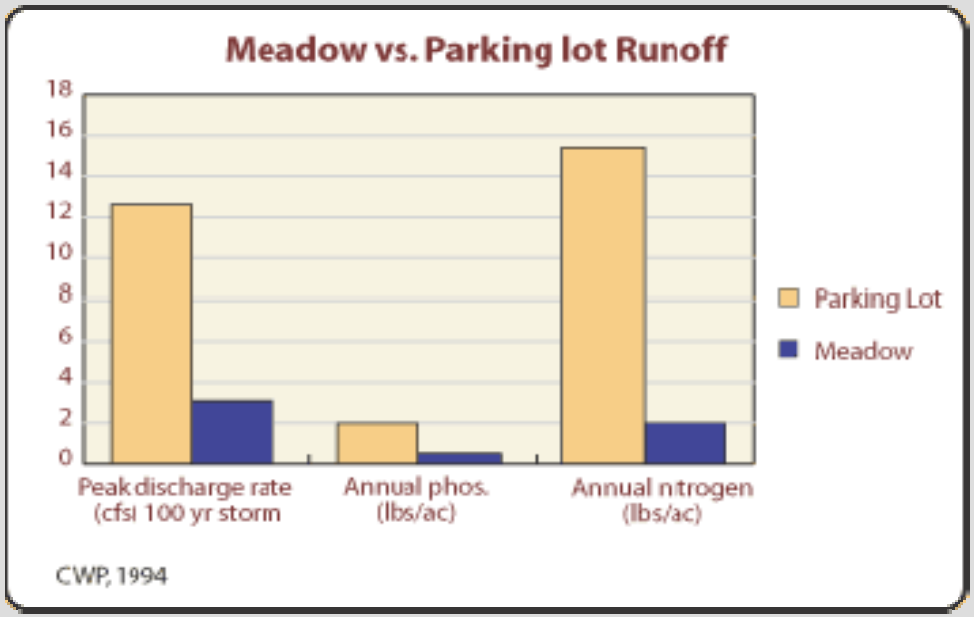
-Hydrology through increased runoff and/or modified streamflow dynamics.

-Air pollution and water quality.

Community Growth

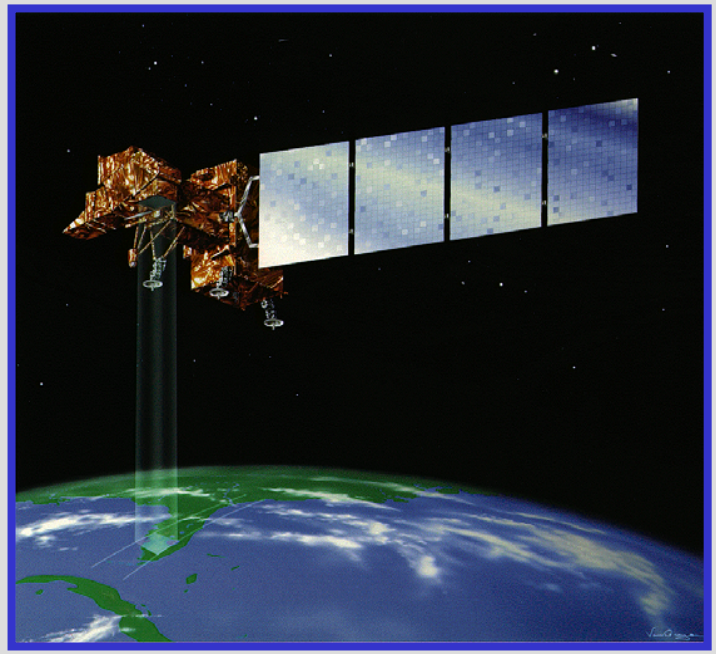
Scientists use Landsat data to generate accurate maps of urban extent and track the changes in impervious surfaces over time.





Landsat 7

- Carries the Enhanced Thematic Mapper Plus (ETM+) instrument.
- Six 30m bands:
  - 0.45-0.52 μm
  - 0.53-0.61 μm
  - 0.63-0.69 μm
  - 0.78-0.90 μm
  - 1.55-1.75 μm
  - 2.09-2.35 μm
- One 15m panchromatic band: 0.52-0.90 μm.
- One 60 m Thermal band.
- 185 km cross-track swath with a 16-day repeat cycle.
- U.S. Geological Survey manages Landsat 7 operations.
- Data archived at USGS EROS Data Center since July, 1999.



Benefits of Landsat 7

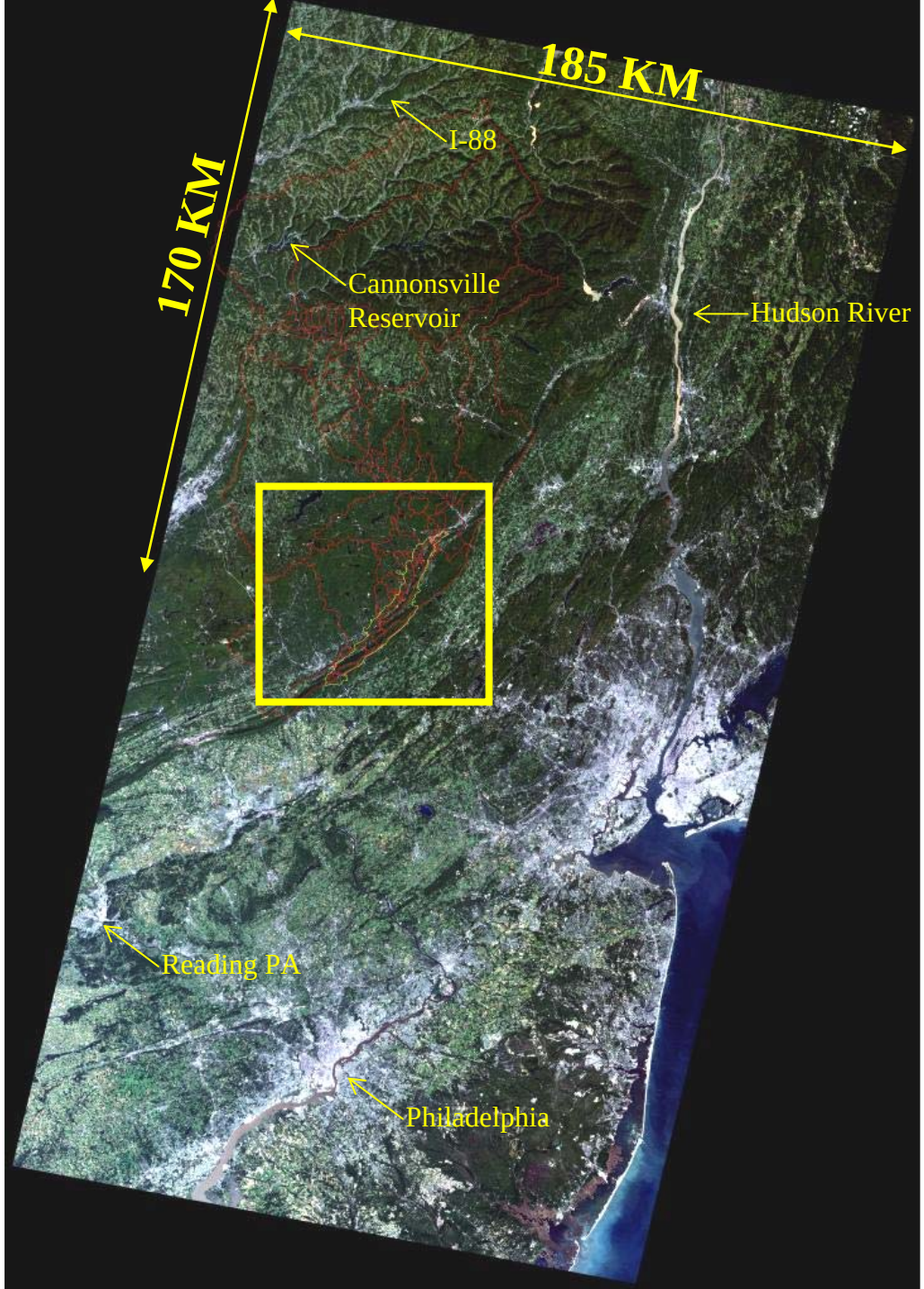
- Cost-effective solution (0.03 cents/ha).
- Synoptic coverage provides regional context.
- Very well characterized instrument.
- Repeat coverage allows for monitoring.
- New data policy allows for openly sharing data.
- Data are useful to address a wide variety of resource management questions.
- Drawbacks:
  - Difficult to map at species level.
  - Cloud cover.


Image by: Stöckli, Nelson, Hasler
Laboratory for Atmospheres
Goddard Space Flight Center
http://rsd.gsfc.nasa.gov/rsd
USGS
Hurricane Linda west of Mexico
September 9, 1997 17:45 UTC
Data from: NASA, NOAA, USGS

Mosaic of two Landsat ETM+ scenes

Acquired on September 23, 1999

3,2,1

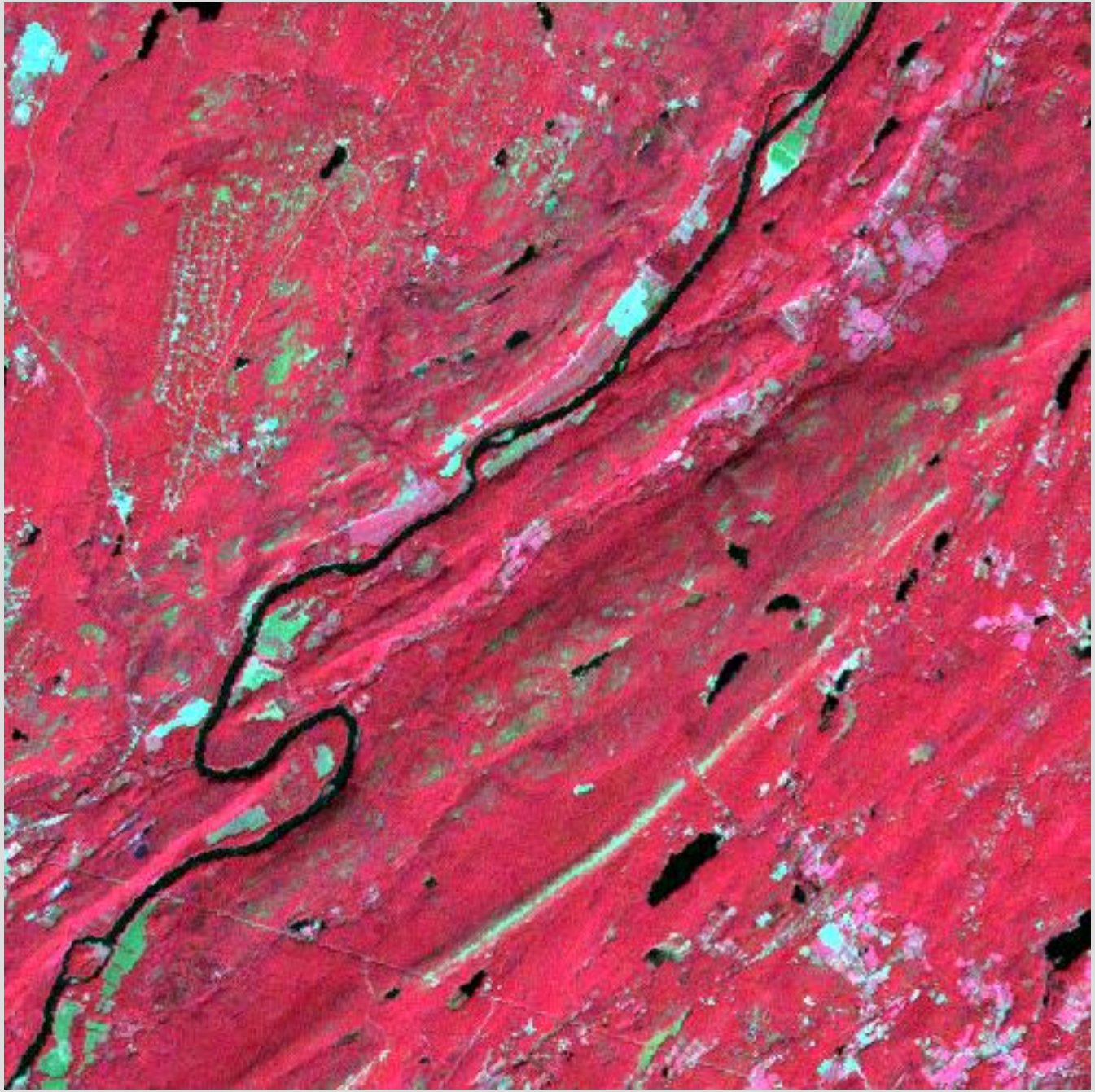



X YOU ARE HERE

DEWA

09/23/99

4,3,2



DEWA

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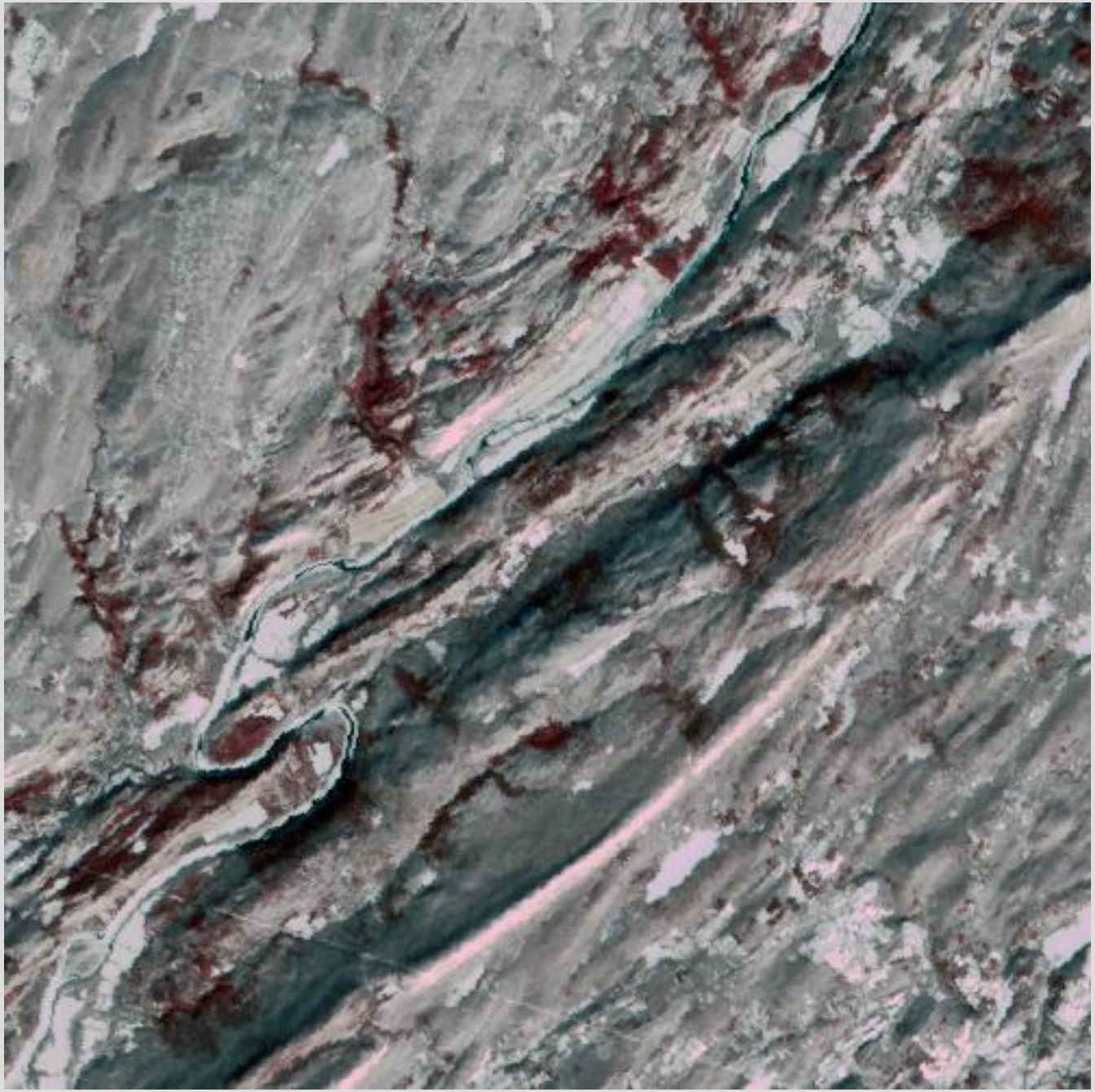


Consequences of Land Cover/Use Changes on National Parks: A Research/Educational Partnership in the Upper Delaware River Basin

- Proposal submitted to NASA's New Investigator Program:
  - P.I.: Eric Brown de Colstoun
  - Education Coordinator: Anita Davis
- Partners include Elissa Levine (NASA/GSFC), Susan Riha (Cornell U.), River Valley GIS consortium (UPDE, DEWA), GLOBE program, **educators/students from area schools**.
- 3-year project to develop tools for land cover/use change monitoring.
- Model consequences of changes on water/energy cycles.
- Structured around existing educational connections between NASA, NPS, area schools and the GLOBE program.
- Mutually beneficial to P.I./educators/students/parks.
- Develop pilot curriculum that includes Earth system science, remote sensing, modeling, etc...
- Response expected February 2004 !!!

Tentative Research Schedule

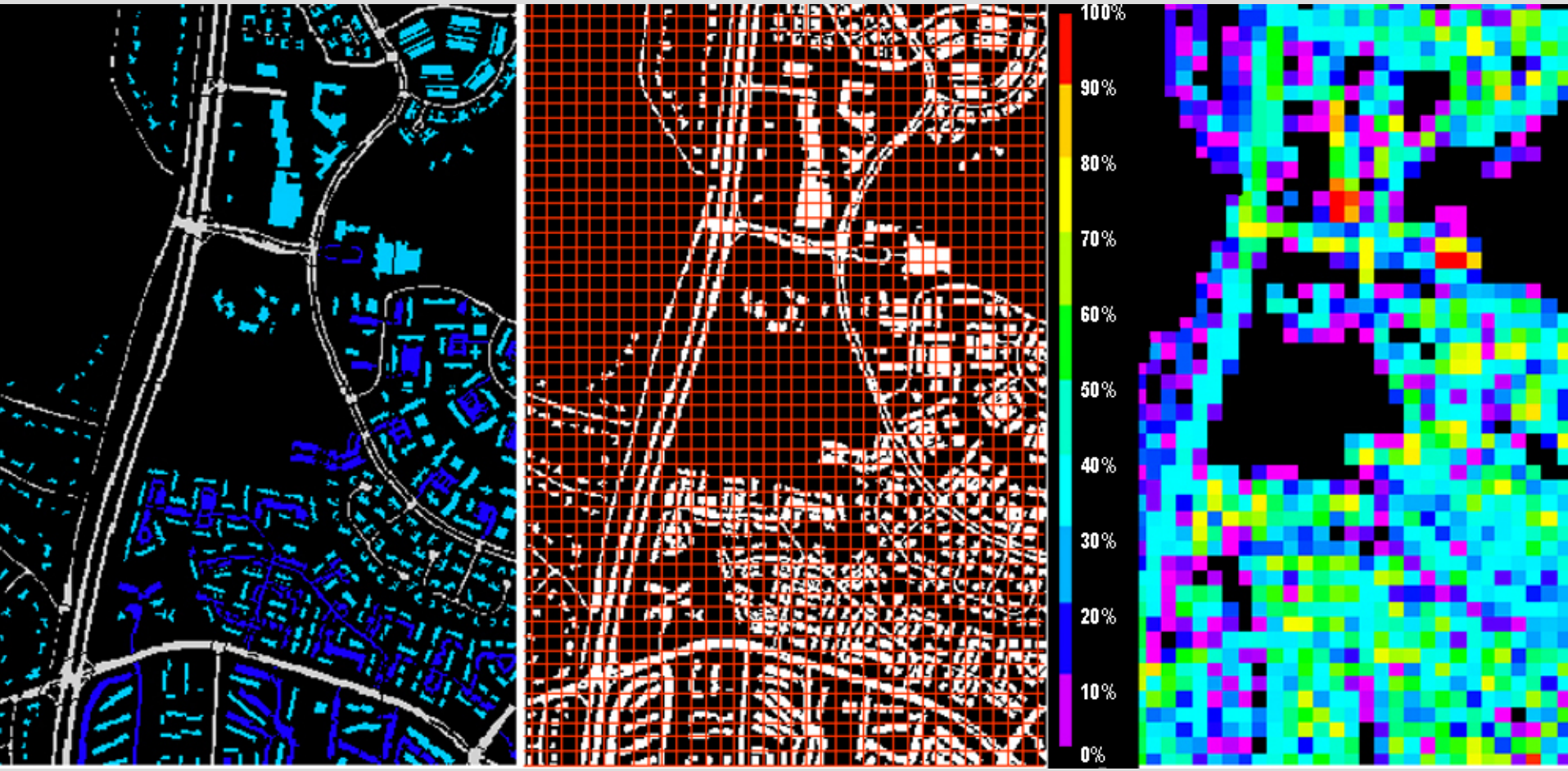
Project Milestones	Year 1	Year 2	Year 3
Acquire Landsat & High Resolution Data			
Process & evaluate results of atmospheric correction (MODAPS)			
Produce & evaluate baseline landcover classification			
Use ground-based measurements from students in GAPS model			
Evaluate & validate protocol & associated products			
Produce final land cover/use change products for UPDE & DEWA			
Conduct GAPS simulation & analysis of model results			
Implement protocol enhancements			
Synthesize & present model & results to science, land management and education communities			
Compile documentation & accuracy information			
Write protocol standard operating procedures			

Mapping and Predicting Land Use Change within the Chesapeake Bay Watershed

Claire A. Jantz, Scott J. Goetz, Andrew J. Smith

University of Maryland Geography Department
Mid-Atlantic RESAC

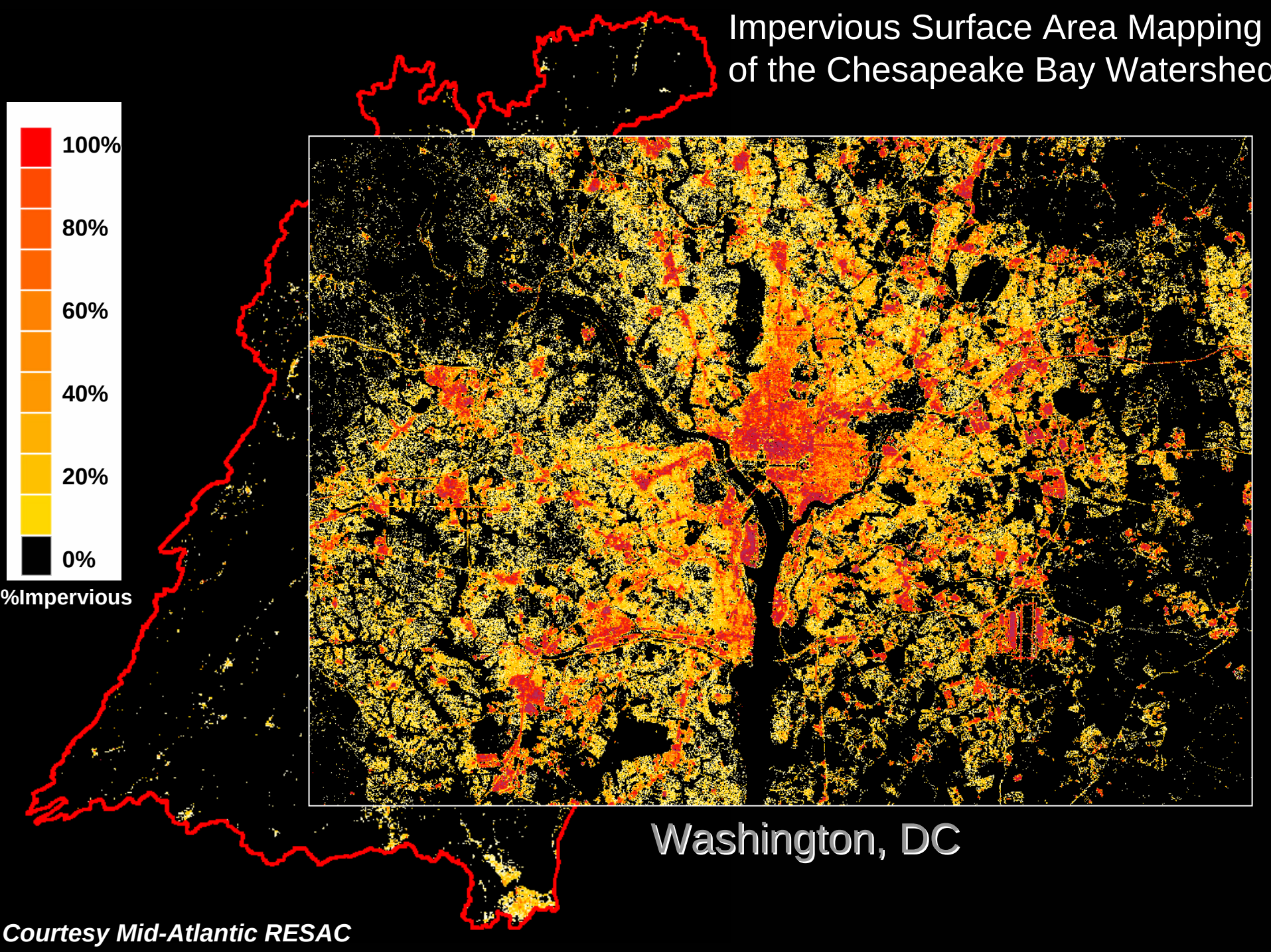
Mapping the Built Environment



Vector Extraction → 3m to 30m Grid → %Impervious Cover

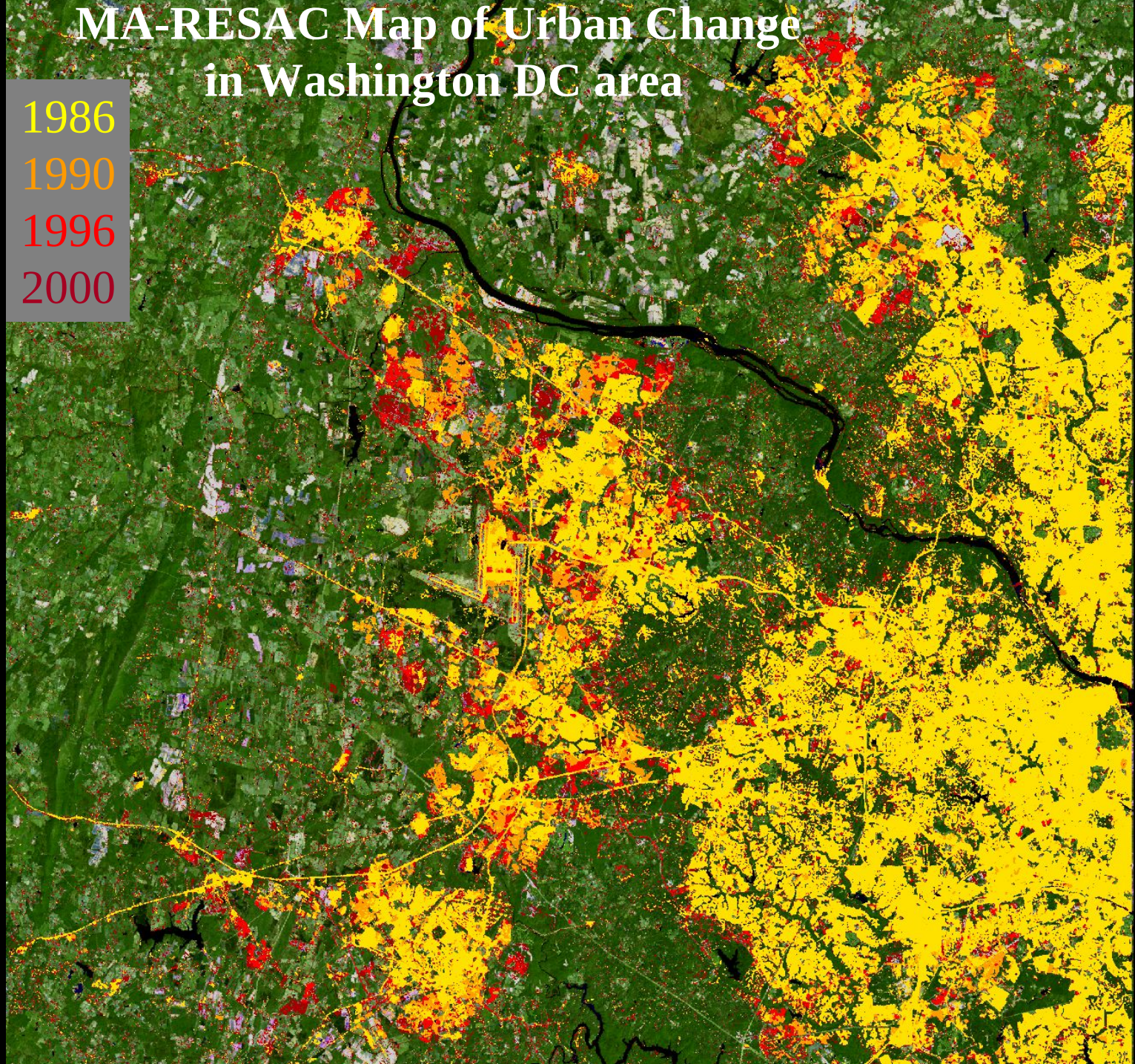
GIS Processing Steps – Training Data

Impervious Surface Area Mapping of the Chesapeake Bay Watershed



Courtesy Mid-Atlantic RESAC

MA-RESAC Map of Urban Change in Washington DC area

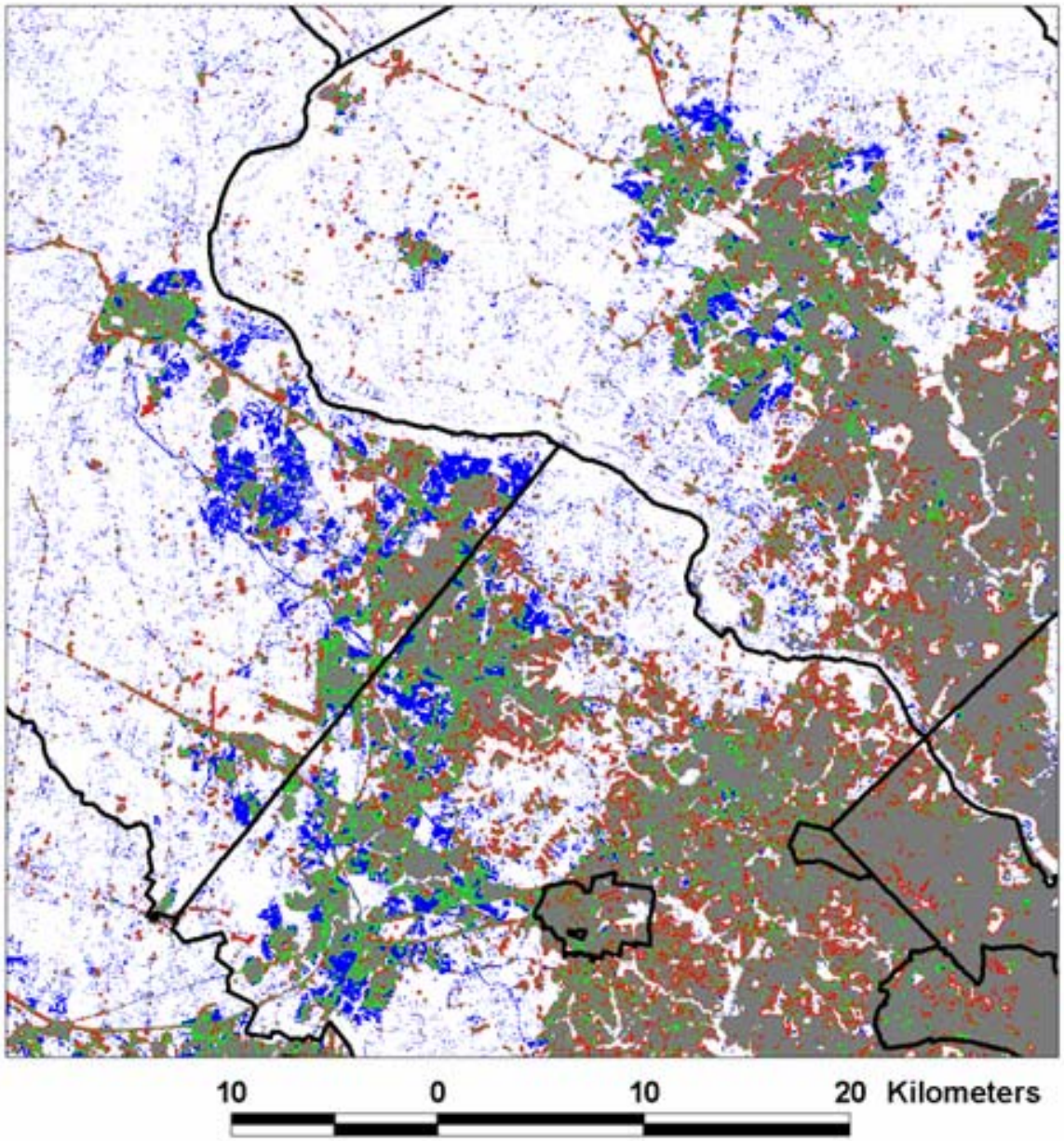


SLEUTH Urban Growth Model

- Urban / non-urban
- Growth rules
  - Spontaneous *(dispersion coefficient)*
  - New spreading center *(breed coefficient)*
  - Edge *(spread coefficient)*
  - Road-influenced *(road gravity coefficient)*
- Resistance to development
  - Slope *(slope coefficient)*
  - Excluded layer *(user-defined)*

SLEUTH Implementation

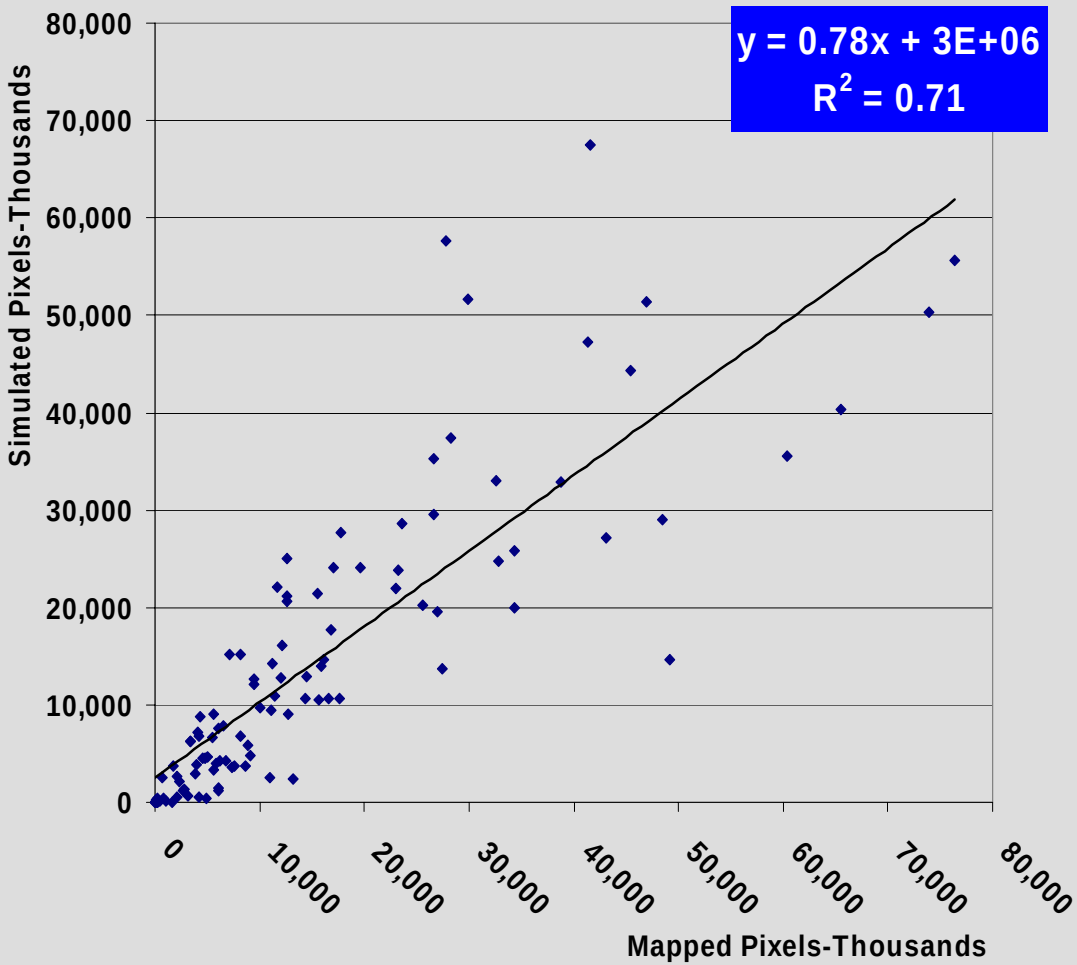
- Calibration
  - Train the model to simulate historic patterns of development (1986-2000)
- Prediction
  - Forecast historic patterns of development into the future (2000-2030)



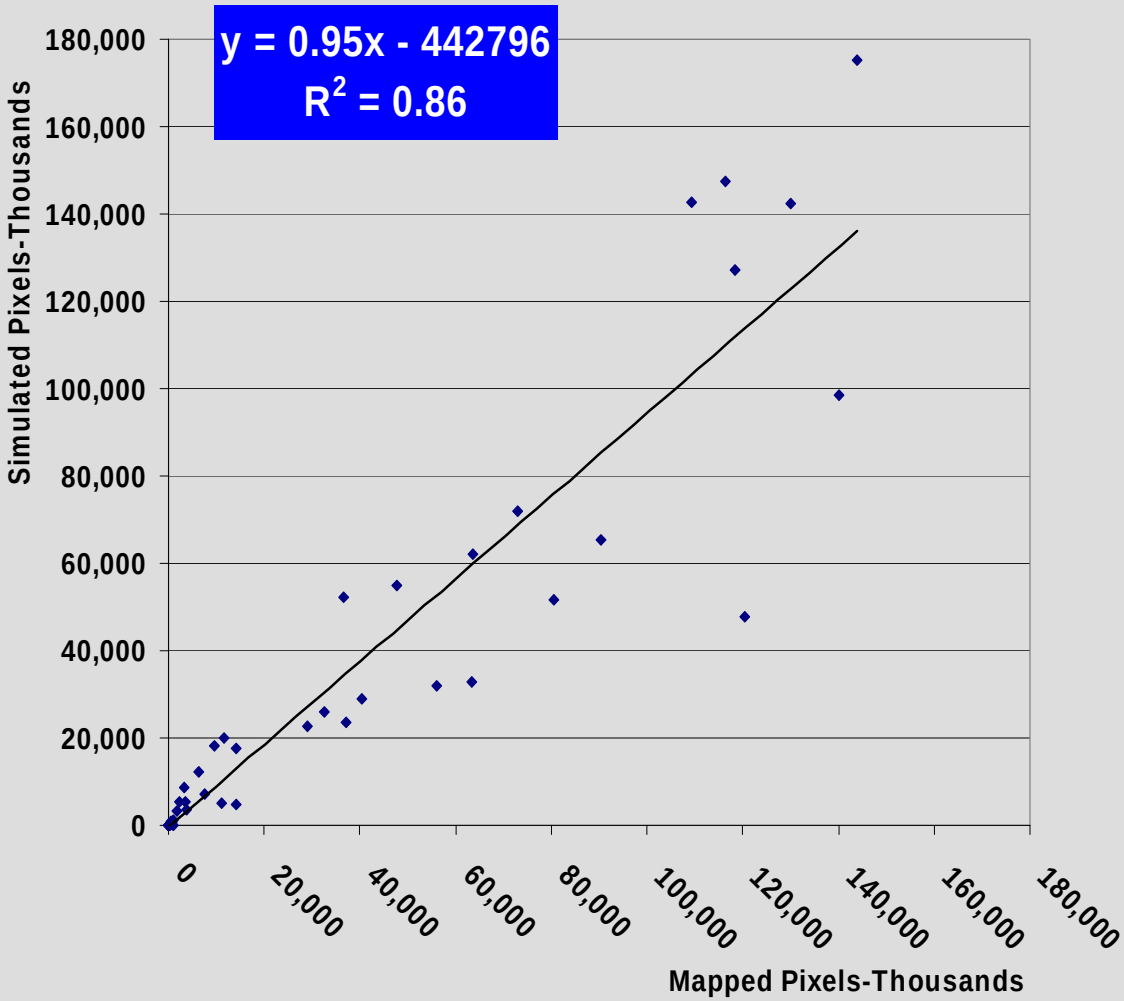
Initial urban extent (1986)
Agreement
Comission errors
Omission errors
Non-urban land

Overall accuracy: 93%
Kappa: 0.19

Model Accuracy: Watershed Scale



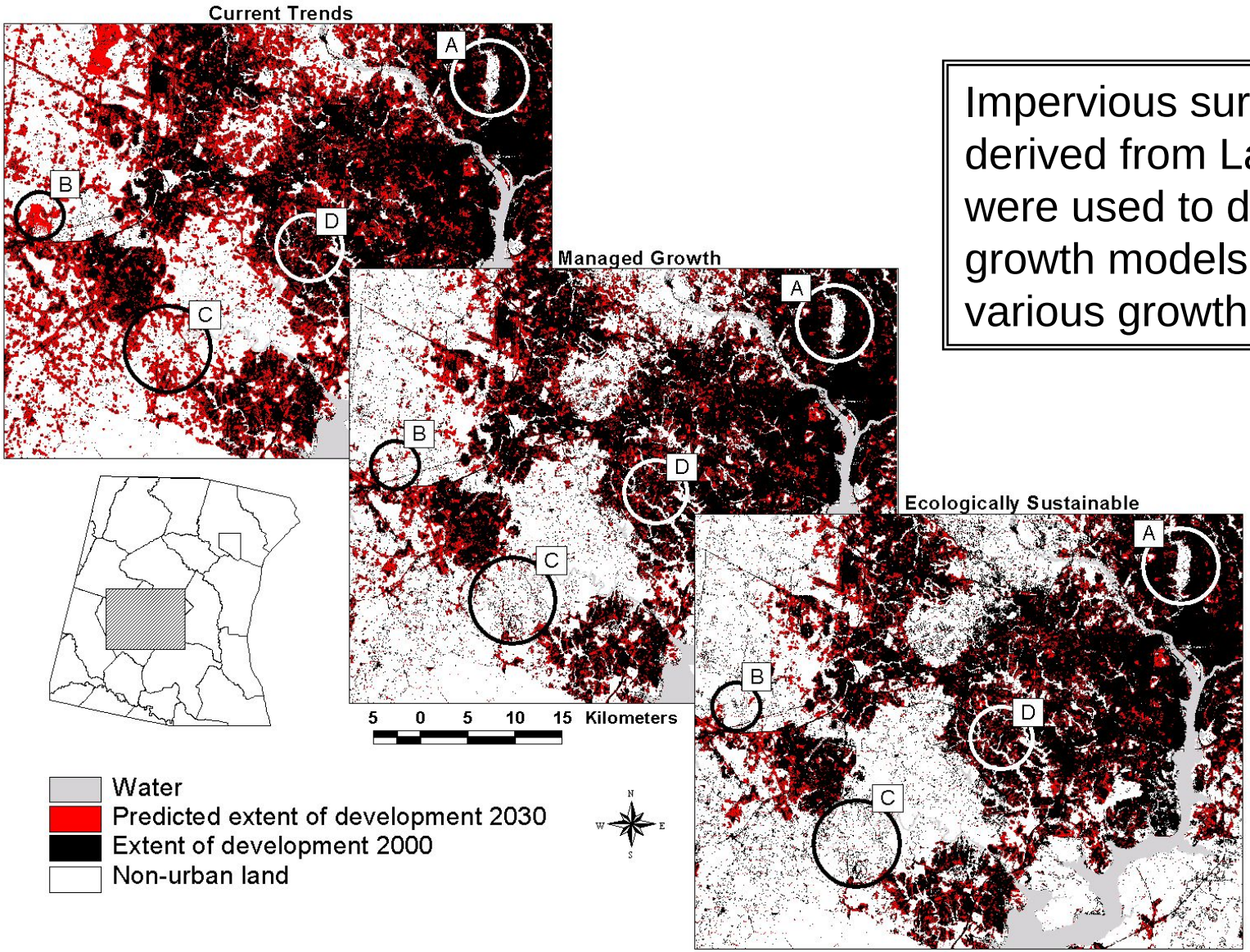
Model Accuracy: County Scale



Prediction 2000-2030

- Initialized with 2000 urban extent
- Scenario development
  - User specified
  - Can be tailored to suit specific policy goals
- Three future policy scenarios developed
  - Current trends
  - Managed growth
  - “Ecologically sustainable”
  - Implemented through excluded layers

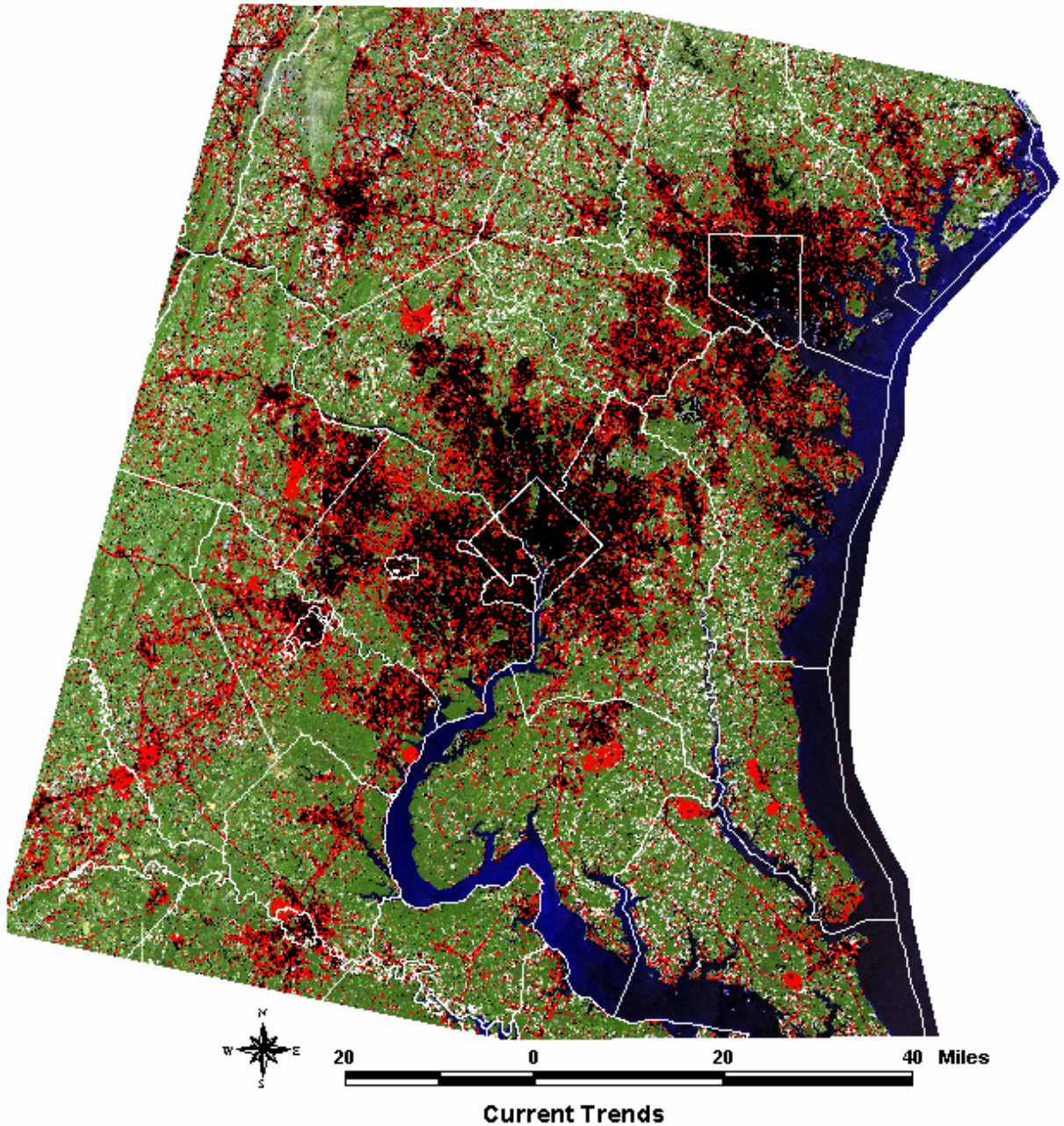
"Smart Growth" in the D.C. Area



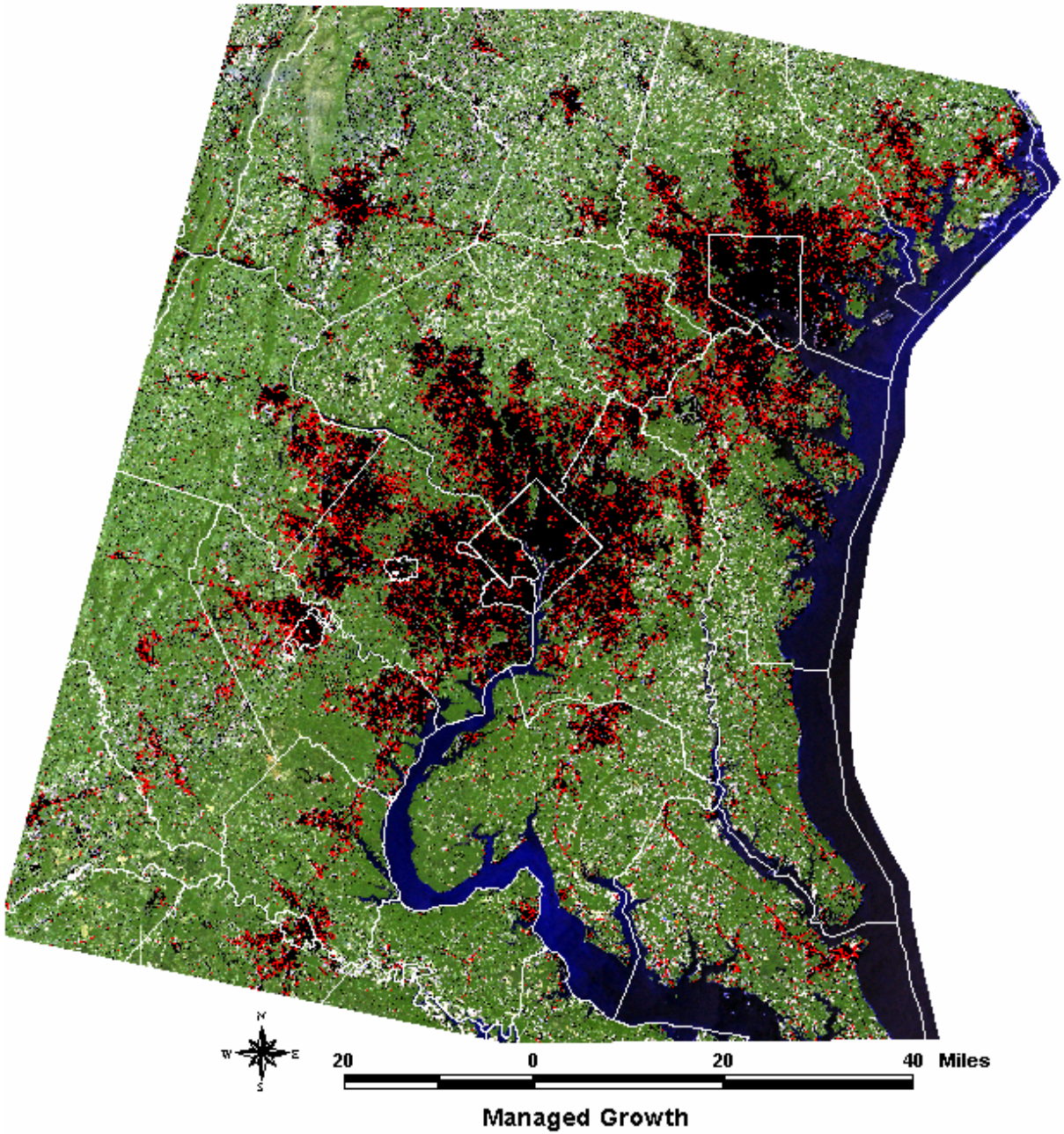
Impervious surface maps derived from Landsat data were used to drive urban growth models under various growth scenarios.

Source: MA-RESAC

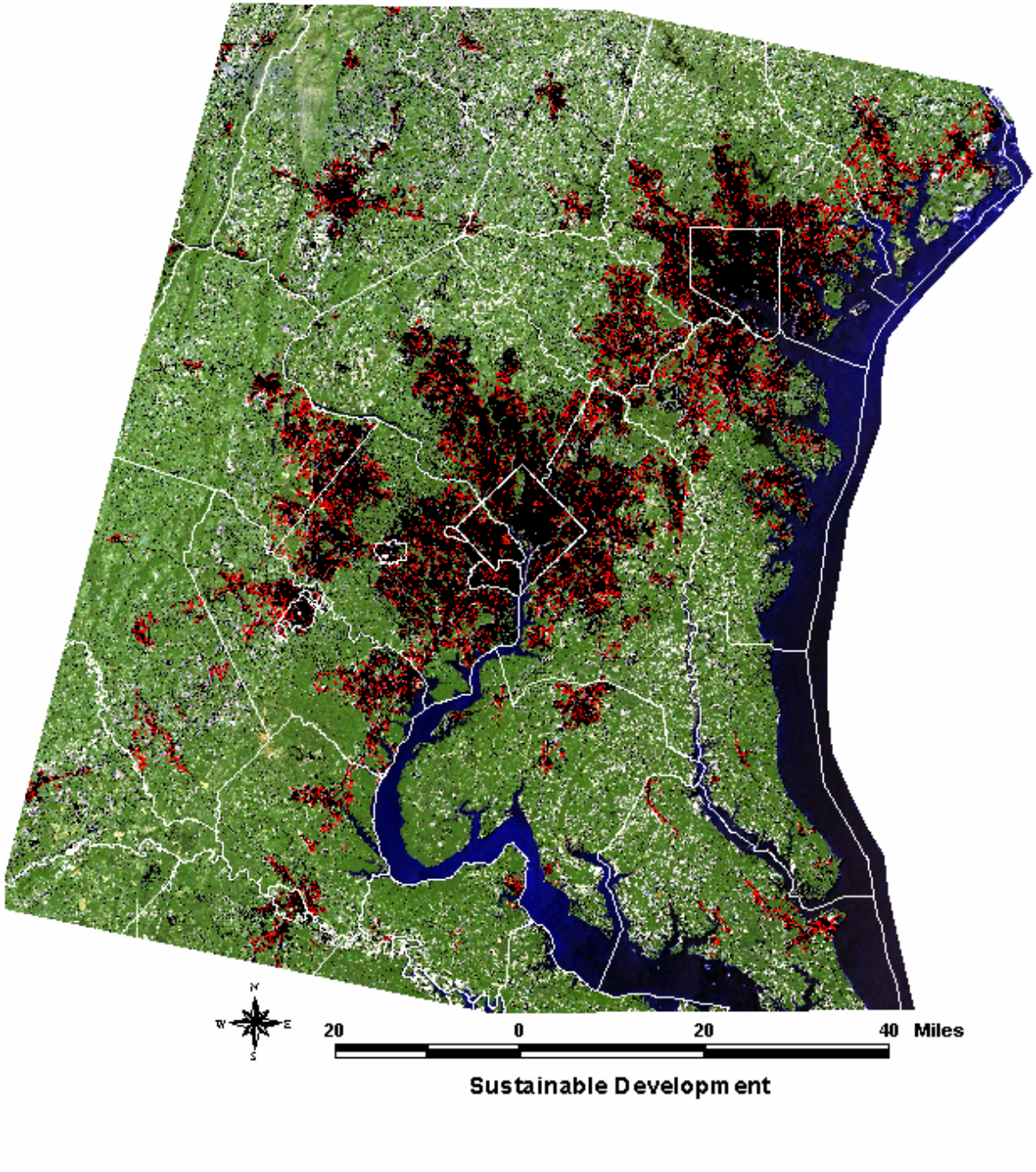
Regional Results



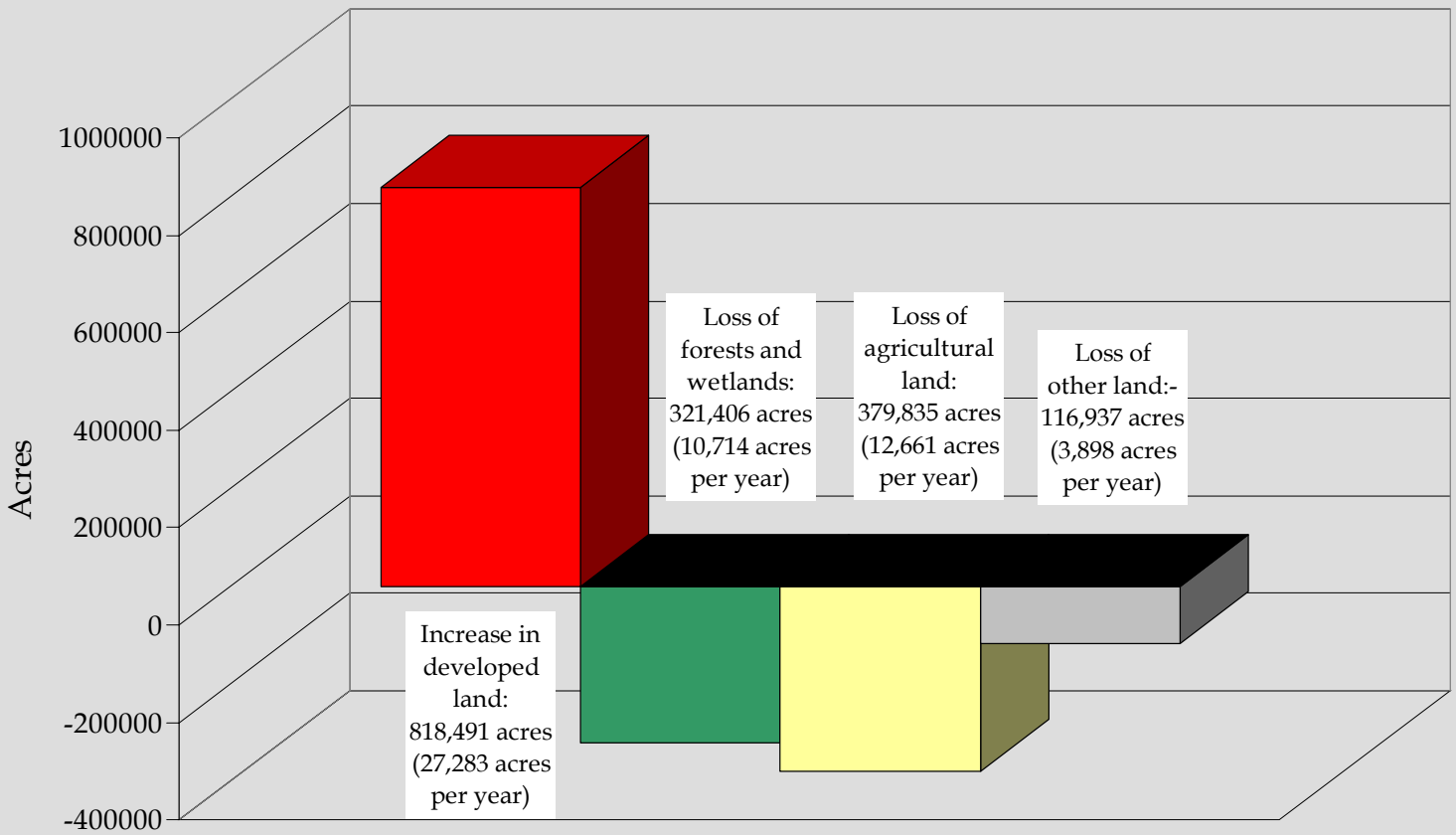
Regional Results



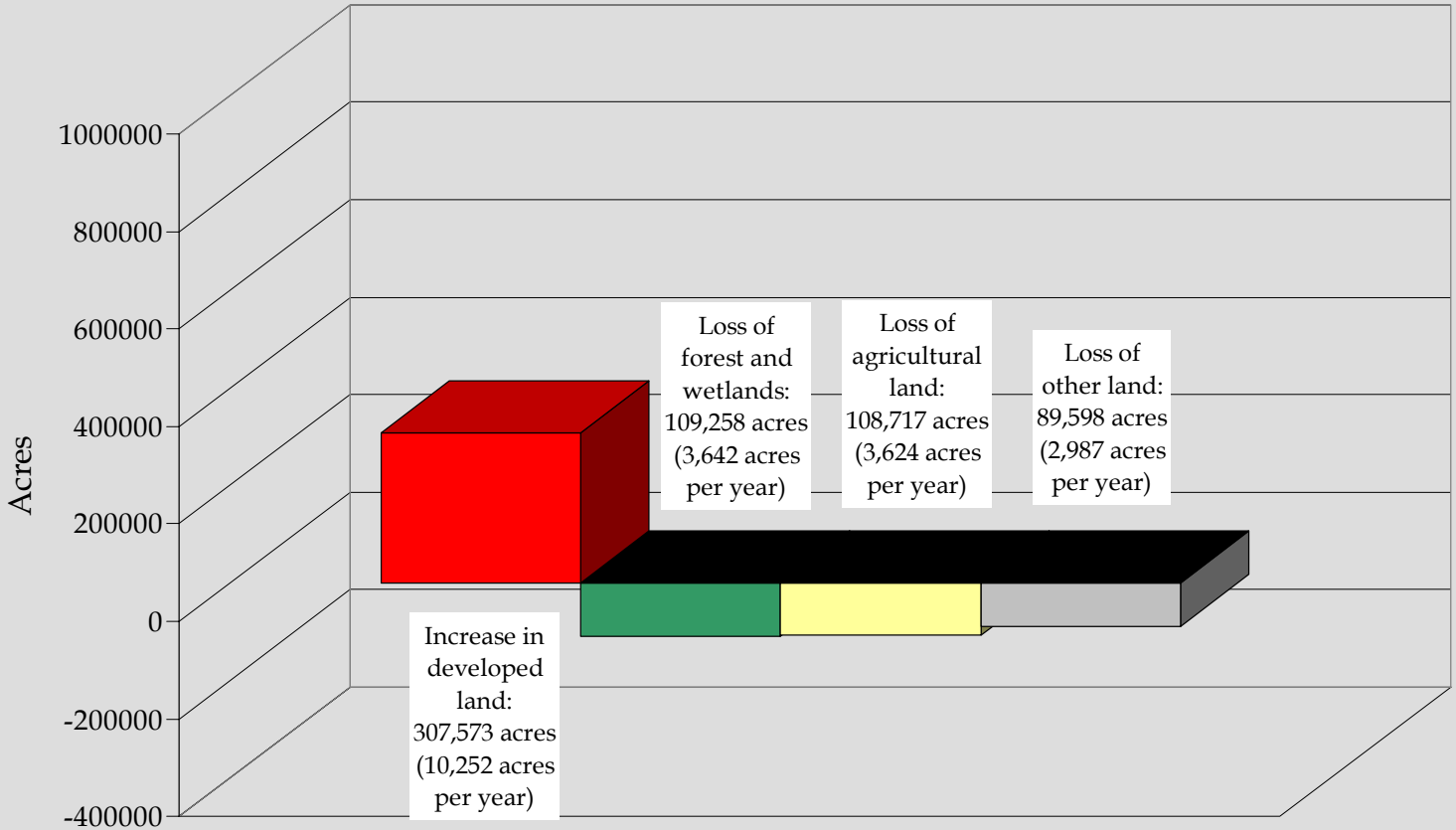
Regional Results



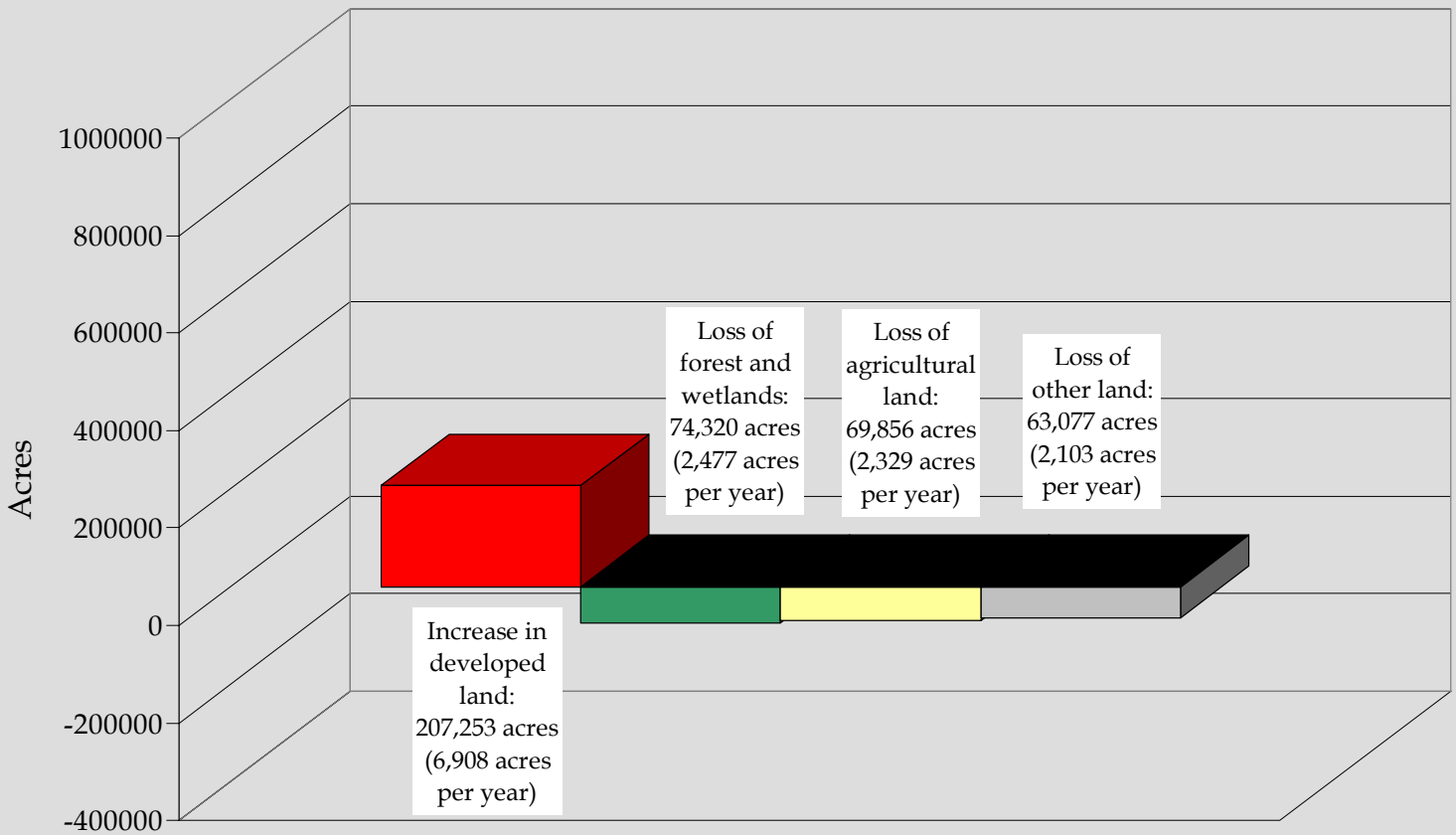
Results: Current Trends



Results: Managed Growth



Results: Ecologically Sustainable

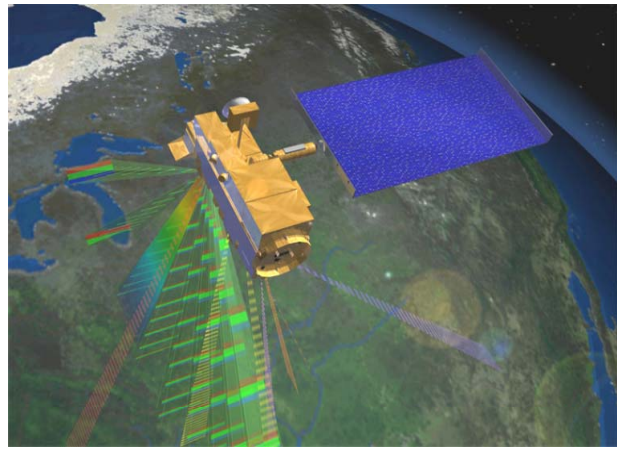


Acknowledgements

- Janet Tilley, Mark Feller, Dave Hester, and Jeannette Candau (U.S. Geological Survey)
- Lee Epstein and Steve Libbey (Chesapeake Bay Foundation)

- More information about this study:
  - RESAC website: www.geog.umd.edu/resac/urban-modeling.htm
  - Forthcoming article in *Environment and Planning B*
- More information about SLEUTH:
  - http://www.ncgia.ucsb.edu/projects/gig/
- More information about the Chesapeake Bay Program:
  - http://www.chesapeakebay.net

Using Remote Sensing Imagery



in Interpretation and Education

- New EOS science results published in lay terms on NASA's new, award-winning Web site:

http://earthobservatory.nasa.gov

Landsat Education Resources:

http://landsat.gsfc.nasa.gov/main/education.html